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17. ABSTRACT (MAX. 250 WORDS)

The major concept of the unit is that something must be done to particles in order to study them. Atoms are composed of two kinds of charged particles -- protons and electrons. Any difference in their numbers results in a charged body. If enough charged bodies are produced, they will affect charge detectors. Conclusions can be drawn from the results. Students are encouraged to build simple devices for use in detecting the presence or absence of electrons. Experiments are performed on nonconductors, with balloons or by boiling, to determine the charge, and students are led to notice relationships between the experiments and to perform other experiments. A simple electron accelerator is used in the classroom.

The sprinkling of salt into a flame, the use of a spectroscope, and the examination of fluorocene in a test tube make students aware that each color of light is a special energy of light. The study of energy changes in the position of electrons is called quantum mechanics.

The recording of data in all experiments is stressed.

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Fable:

Once there was a blind man who lived in the deep woods. All was peaceful and quiet. He decided that he needed a vacation and walked several miles further into the woods where he fished and [illegible]ed for several months. Upon his return home, he was much distressed to find a new noise (they had built a super highway past his door while he was away). Before long, he concluded there were particles whizzing past his house and he, being curious, wanted to study them. After many trials (and one broken arm), he discovered that if he timed it just right, he could drop a large tree in the road and detect with his ears the capture of one of the whizzing objects. He could then gather up the object and take it to his cabin for careful study. Some examples of his findings - (1) the objects were always composed of some broken glass and wrinkled metal. (2) Generally they had wheels attached, in numbers from 1 to 4 or five. (3) Generally one end was [illegible] the other - and so on. A description of the whizzing objects contains much truth, buth the process of capture leaves many questions unanswered. Where were they going? How much did they change while being captured? Where did they come from?

By this time you should see the point of the fable. In order to study these particles, it becomes necessary for us to do something to them. This is a major problem in our study.

We shall now pursue two courses of investigation and join the two in a third lesson.

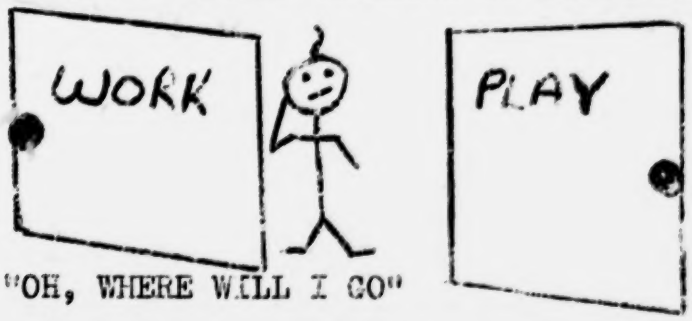
Atoms are composed of two kinds of charged particles: protons (+) and electrons (-). If the numbers of protons are the same as the electrons, the total charge is zero. Any difference in their numbers results in a charged body. If we can produce enough charged bodies, they will affect our charge detectors and we can draw some conclusions from the results. These charged bodies, resulting from unequal numbers of protons and electrons in atoms (or molecules) are called ions. It would be wise to draw some possibilities for ions of different atoms to be sure that you understand the possibilities.

As we proceed through this unit, you should keep the introduction fable in mind.

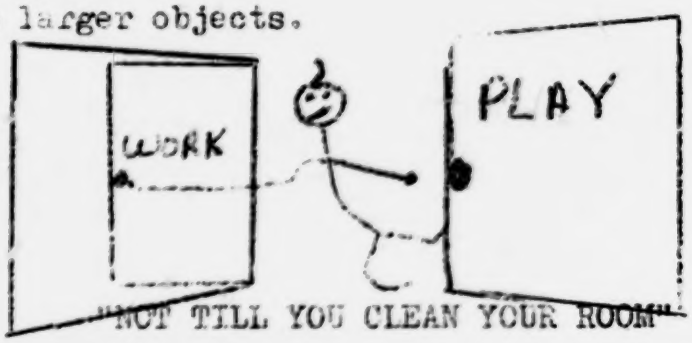
Electrons everywhere! Look about you. You will find that there are a great many electrons not doing anything. There are loose electrons on your desk, on your fingers, on your clothers - everywhere.

Sometimes these electrons get in a pile on you, and when you touch the car door or a water pipe you get a shock. You may even be able to see a spark jump. Sometimes large numbers of them get moved to one place and a large spark (called lightening) can be seen when they go from where there are lots of them to where there are not so many. Normally, these electrons are spread out pretty evenly (like water, I guess but with a little understanding, we can learn to work with them and see how they behave.

All of us have combed our hair and used the comb to pick up bits of paper. Maybe our hair crackled or stood on end (it has to be quite dry). You may go one step further and use a cat's fur and a larger piece of plastic to get a better transfer of electrons, and pick up larger objects.

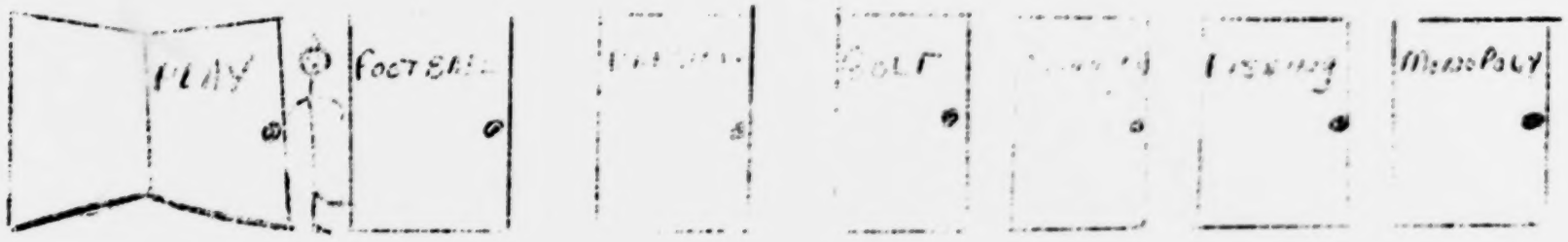


"OH, WHERE WILL I GO"



"NOT TILL YOU CLEAN YOUR ROOM"

Just like you, electrons have preferences. If they have a choice of two places to be, one place may suit them better. March the students in the room up to the two door and let them choose - you will get more through one door than the other. Just so with electrons. In conductors (what are these?) they can run around but in non-conductors they are stuck where you put them until they can escape. Which type of material would you choose if you didn't want to loose them?



Given a choice, one activity may be more popular than another. The electrons may be attracted to one substance more than another. You may have rubbed the rod real hard, expecting that some sort of work is knocking them loose, but it isn't. All that is required is that you provide an electron with a space on the place of its preferende. You can read a book about this and it will tell you that a rubber rod rubbed with fur will take on electrons. We say that the rubber rod has become <u>negatively</u> <u>charged</u>. We already said that electrons will go from where they are to where they aren't (if it is still in the material of their preference). What would happen if another rubber rod, just like the first, were brought in contact with the first? If the rubber rod, rubbed with fur, will attract paper, what about the fur? Suppose that we rub a balloon with cat's fur. What is the balloon made of? What do you suppose will happen if you rub the balloon with fur? Try it. Rub two balloons with fur. How do they react to each other? How do they react to the fur? To a charged rubber rod? What attracts a negatively charged balloon? What repels it? State what happens generally in as brief a statement as you can and have it accurate. Try other things. Charge the balloon with cat's fur. What is its charge? Rub a piece of glass with silk. What is its charge? How can you show this?

There are simple devises that you can make that will detect the presence of many electrons or the absence of many electrons. See if you can find out what they are and build one at home. It will aid you in your study.

Find several non-conductors and try to establish the charge on them.

By means of two balloon, experiment and see how the force between two charged objects changes as you charge the distance between them.

Electrons can be boiled off certain materials and made available for study. When we study these we find, sure enough, they are repelled by a rubber rod that has been rubbed with fur. We are able to isolate another particle that is much heavier than the electron but behaves in an opposite fashion. It is attracted to the charged rubber rod. We called it the proton.

Since the proton is not found loose in nature the way the electron is, it is not as readily available to you, but its behavior is predictable if you

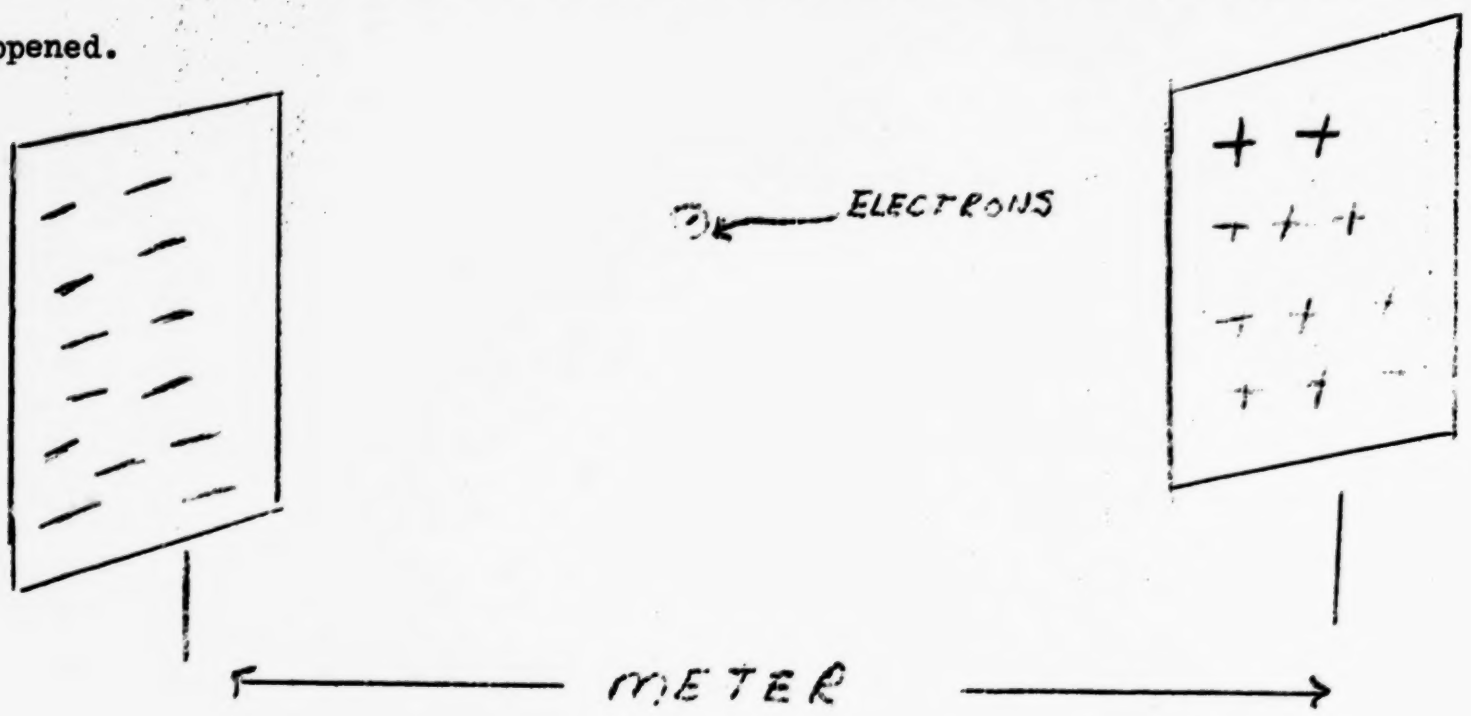
understand the rules for the electron and consider a few other facts. Let us now ignore the proton and go back to the electron.

Our work with the electrons so far has been with static electrons, and our evidence has not been due to seeing the electron. Rather, we have seen the effect of the electron and applied reason to tell us what must have happened.

Electrons are there, true enough, but what are they doing? What do they look like?

Sometimes we can find similar events in rather unrelated situations. These situations make it easier for us to see the relation or predict what is happening. We can use an optical bench to illustrate a common phenominon. An optical bench is a meter stick with feet. If a light bulb is placed on one end of the stick and a piece of cardboard with a hole one centimeter square (be as exact as you can!) is placed at about the 10 centimeter mark, the light that escapes through the hole is a square column of light. Use another card and move it until the light covers a square of 2 centimeters on an edge. Record your distance from the first card. Now let the light cover a square 3" on an edge. How far away is it? Try a 4" square, 5" square, etc. From your findings, what can you conclude? Now suspend a balloon from a thread from the ceiling and attach another balloon of the same size to a stick. Charge one of the balloons with cat's fur or wool. Let the two balloons touch. What do you suppose happened to the charge?

Now try different distances apart for the balloons. Consider the action of gravity in this. What happens as the balloons are moved closer together? Can you find a relationship between the experiment with light and the experiment with the balloons? How could you improve the experiment to give you better results? Look in some science books and see if you can find a law that will explain what happened.



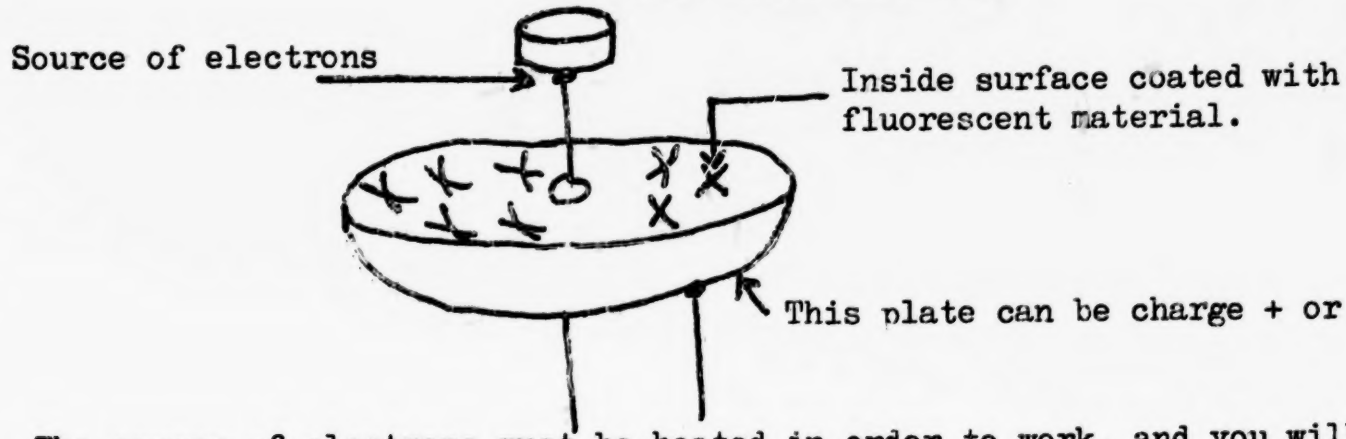
Suppose that you had a large positive charge and a large negative charge placed a meter apart. Now imagine an electron placed right between the two. What will it do? Describe its motion until it stops. (Keep in mind all of the experiments you have already done).

Suppose that we double the charges. How would this affect the motion of the electron? What would happen to several electrons in between the charges if they were placed there at the same time and at the same distance form the charges? Suppose they were at different distances from the charges . What would the effect be?

So far we have studied electrons that are standing still and not really tried anything with moving electrons. We know that electrons flow when we use electricity. A magnetic compass will be affected by a wire that carries electricity (try this at home. if you have a compass). This might help you in your investigation later.

Before we proceed, there is some information that you should have moving electrons can have considerable energy. The results of this energy is familiar to you in the X-ray, where moving electrons strike a metal and cause the production of X-rays, and in television, where moving electrons strike a material and cause it to glow. As you might suspect, the moving electrons are affected by magnets and charges. We have set up an apparatus for you to investigate some of moving electrons. The apparatus consists of (1) a tube in which electrons can be obtained and moved (2) a devise for changing the speed of the electrons.

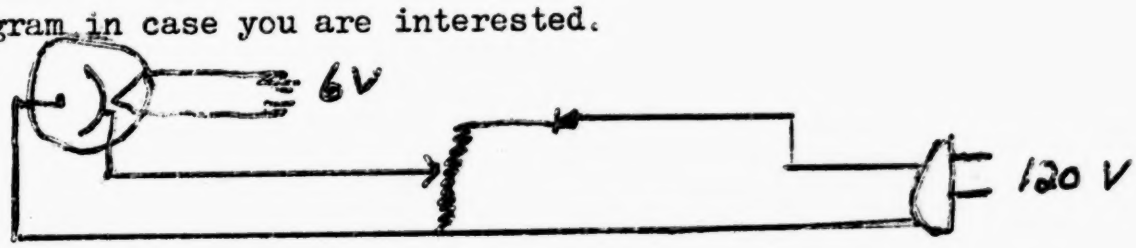
The Tube Looks Like This



The source of electrons must be heated in order to work, and you will see it glow. How should we charge the plate in order to attract electrons to it? What should happen if we change the size of this charge?

We have built a method of changing the charge on the plate, so that all you have to do is turn a knob. This is similar to turning up the volume on your radio or television. When you can see that the tube is heated, plug in the charging section. Vary the size of the charge. How can you tell what happens? When do you suppose you have the greatest charge on the plate?

Here is a wiring diagram in case you are interested.



How would this be changed to investigate protons?

Use a rod charged negatively to investigate the moving electrons. How do they behave at different speeds? How does the rod affect them? Keep careful records.

Now try a magnet on the electrons. Be careful, for there is some metal in the tube that will be attracted to the magnet and you can break the tube. Do the electtons respond to both poles of the magnet in the same way? Find as many differences and similarities as you can between the magnets and charged rods.

By this time you should have a general idea of how an electron accelerator works, for you have used a simple one and experimented with the electrons. Many other devises are used to investigate the electron and they use equipment much like the equipment you have used. The mass of the electron can be found by adding a variable magnetic field to the apparatus that you have. We are not going to do this in this unit, but it is possible.

Consider your results of your earlier experiment. How would they differ if the electron were, say 1000 times heavies than it is. Make a table of comparisons. If If electrons came in three weights - regular, 10 times as heavy, 100 times as heavy - how could you sort them out? Would this work for any charged particles?

In the tube, we boiled out electrons that were part of an atom before heating. When we knock an electron off an atom, we say we have ionized the atom, and it becomes an ion. If we just jiggle the electrons in the atom, we call this an excited atom. We have many examples of excited atoms and the incandescent light is one of the most familiar. Electrons seem to exist in an atom in favored places. Models for the atom refer to these favored places as orbitals, orbits, energy levels, etc., but they all indicate rather specific regions. It requires energy to move an electron from a favored place near the nucleus to a favored place further away from the nucleus.

Light is a form of energy, and since we have detectors available to us, it is an easy one to use. Light covers a range of energy from the low energy red light to the high energy violet light, and each color of light is a special energy of light. We can use this a a guide.

If you sprinkle some table salt into a flame, you will see a bright yellow color caused by the sodium in the salt. (How do we know it is the sodium?) Other elements give different colors. Try several and set up a table of colors. By your own process decide what element contributes the color you see. Construct a data sheet before you start, and a reference thabe of your finding for later use.

In some cases, so many different light energies are given off, that we see a white light. In other cases, one strong color may hide several weak colors. We sutdy these energies by means of a spectroscope that breaks up light into its individual colors. Some will be available for you to look through and see the difference between what you see and what the spectroscope shows you. Draw what you see in the spectroscope. Find out if what you have been seeing is an emission or absorption spectra.

Another interesting material is Fluorocene. If you put a solution of fluorocene in a test tube, it will appear a different color when viewed from different positions. Is this emission or absorption? Explain

These methods are used in the identification of elements and compounds and both depend on energy changes in the position of electrons. Since these changes are specific amounts of energy, they are called quanta (bundles) of energy, and the study is called quantum mechanics.